AD _____

REPORTS CONTROL SYMBOL MEDDH - 288 (RL)

A STUDY OF THE ECOLOGY OF MALARIA VECTORS IN THE REPUBLIC OF PANAMA.

FINAL REPORT

JULY 1968

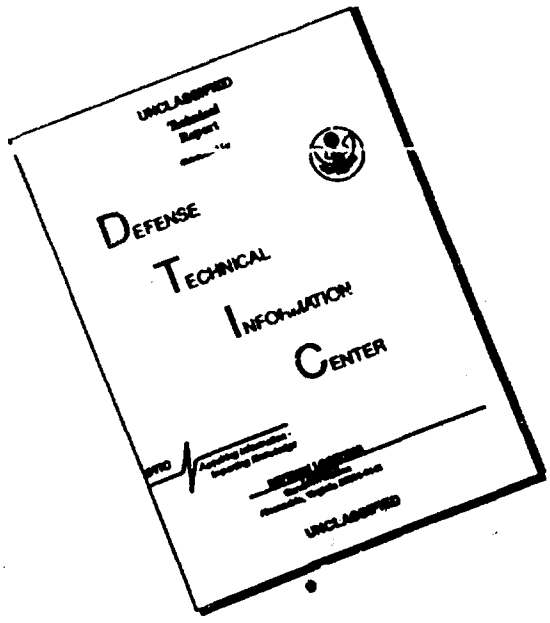
by

ROBERT M. ALTMAN, COL, MSC

OFFICE OF THE CHIEF SURGEON
HQ USARSO
Fort Amador, Canal Zone

28

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

ABSTRACT

Project No. 3A635301D329 Title: Malaria Prophylaxis

Sub-Task No. 037 Title: A Study of the Ecology of Malaria Vectors in the Republic of Panama

Advice of Obligation Authority: A21X2040 706-8019 5695-25 (5695 1000 829 00 0/6740 7978) S49-193

Name and Address of Reporting Agency:

Office of the Chief Surgeon
HQ USARSO
Fort Amador, Canal Zone

Period Covered by Report: 1 October 1966 - 13 July 1968

Professional Author of the Report:

Robert M. Altman, COL, MSC

Reports Control Symbol: (MEDDH-288)

Security Classification: Unclassified.

Unsuccessful attempts were made to colonize Anopheles oswaldoi, A. punctimacula, A. eiseni and A. apicimacula. Sixteen unsuccessful efforts were made to infect A. oswaldoi with malaria by feeding them on monkeys infected with Plasmodium vivax, A. albimanus fed on the same animals at different dates became infected. Nine malaria surveys were made in the Darien Province, R. P. and many mosquitoes were collected and examined, but only one A. albimanus was found infected. It appears that A. albimanus is the primary malaria vector in the Sambu and Jaque River Valleys although other species may be secondary vectors.

Aerial spray tests were conducted at Frijoles, C. Z., against Anopheles spp. with technical Malathion and Fenthion. Fenthion applied at 0.32 pounds/acre gave 95% reduction after 25-30 hours, malathion at 0.62 pounds/acre gave only 85% reduction after 25-30 hours. Smaller dosages of both chemicals were less effective.

The insect repellents N,N-Diethyl-m-toluamide (deet), 2,2,4-trimethyl-1,3-pentanediol, dimethyl phthalate, N,N-diethylbenzenesulfonamide, ethyl hexanediol and M-2020 were tested against Anopheles albimanus at Frijoles, C. Z. All the repellents except N,N-diethylbenzenesulfonamide

provided protection for over 135 minutes at the highest concentrations tested. In additional tests with ethanol dilutions deet was more effective than the other repellents.

Laboratory and field tests were conducted to determine the effectiveness of insecticide residues on Army tenting against Anopheles spp. Malathion, Chlordane and DDT were ineffective after one week. Dursban was the most promising insecticide tested.

Satisfactory adult mosquito control could not be obtained with the Mity Mite backpack insecticide sprayer. When the sprayer was modified to use concentrated Fenthion and Malathion acceptable adult and larval control was obtained although the machine is of limited value in the field because of weight.

Satisfactory equipment was designed and constructed for mounting on H-13 and UH-1 helicopters for spraying concentrated insecticides.

A dispenser, insecticide, solid, rotary wing aircraft was service tested for the Combat Development Command.

Sub-Project No. 3A635301D329 Title: Malaria Prophylaxis

Sub-Task No. _____ Title: A Study of the Ecology of Malaria Vectors in the Republic of Panama

Description:

This project was designed to study the biology and ecology of the Anopheles spp. mosquitoes in the Republic of Panama to determine the relative importance of the various species as malaria vectors and develop methods for controlling them. The study was conducted in Darien Province Republic of Panama and the Canal Zone. Portions of this study were conducted in cooperation with personnel from the Gorgas Memorial Laboratory, Panama City, R. P. and the USDA, ARS Entomology Research Laboratory, Gainesville, Florida.

Progress:

I Laboratory Procedures

A. Insect Rearing

A sub-colony of the Anopheles albimanus Wiedmann from the Number 1 laboratory strain was established with specimens obtained from the SNEM (Servicio Nacional de Erradicacion de la Malaria), Panama City, Republic of Panama. The adults were fed on Guinea pigs. The larvae were fed a three part, by weight mixture of dehydrated yeast, Kellogs concentrate and Kretschmer wheat germ. Larval growth was stimulated by putting crashed green grass into the larval pans. No difficulty was experienced in maintaining this colony.
Unsuccessful attempts were made to colonize Anopheles oswaldoi Lutz,

A. punctimacula Dyar and Knab, A. eiseni Coquillett and A. apicimacula Dyar and Knab. The insects could be reared from egg to adult in the laboratory, but would not mate. Forced copulation was attempted, but no sperm transfer was obtained.

The majority of the mosquitoes were collected in a horse-baited insect trap located in Mojinga Swamp, Ft Sherman, C. Z. The engorged mosquitoes were aspirated into one pint ice cream cartons covered with nylon bolting cloth. The containers of mosquitoes were transported to the laboratory in chilled insulated pathological containers. In the laboratory the mosquitoes were lightly anesthetized with ether and each species placed in separate ice cream cartons with the bottom covered with moist cotton and filter paper. The mosquitoes were held at 80° F and 80% relative humidity until they oviposited. The eggs were retained on the moist filter paper for 24-36 hours, then placed in trays of tap water containing small amounts of the larval food and crashed grass.

Anopheles oswaldoi were selected for intensive colonization attempts because it was found to be the most numerous species in several areas of Panama where there had been a high incidence of malaria. From 14 July 1967 to 13 January 1968 many engorged female mosquitoes were processed for eggs as described above and a total of 20,579 pupa were obtained. The average daily pupa production was 125 and the maximum number for one day was 959. The average time from first instar larvae to pupa was 10.5 days, 9% pupated in 8 days and 2.6% did not pupate until the 14th day.

Two hundred thirty one (231) engorged gravid A. oswaldoi were placed singly in shell vials containing moist cotton and filter paper discs to determine the number that would oviposit. After oviposition the eggs were flooded in the same vial and the viability was determined. One hundred sixty (160) of the mosquitoes oviposited and there were one hundred thirty one (131) viable egg masses. Fifty two percent (52%) hatched in one day, 43% in two days and 5% in three days. Anopheles oswaldoi were repeatedly placed in one cubic foot square screened cages, 15.625 cubic foot square screened cages and cylindrical cardboard cages 12 inches in diameter and 14 inches high, given a blood meal and held to determine if they would mate. Forced copulation, before and after blood meals, was attempted. Coupling occurred, but there was no sperm transfer.

B. Malaria Infection Experiments

Sixteen experiments were conducted to determine if Anopheles oswaldoi could be infected with malaria. The experiments were conducted in cooperation with Dr David Baerg of the Gorgas Memorial Laboratory. In two of the experiments the Black spider donor monkey was infected with Plasmodium braziliensis, in all the others the splenectomized night monkey donors were infected with P. vivax. Infection attempts with A. albimanus from the Number 1 laboratory strain were made at the same and other dates. The A. oswaldoi fed very poorly and there was high mortality. None of the A. oswaldoi became infected. A. albimanus were infected on four of the seven night monkeys used, but not on the black spider monkey. However, in only one of eighty two

feedings was a A. albimanus mosquito infected on the same date that the A. oswaldoi failed to become infected. No conclusions can be formed from these experiments as to the ability of A. oswaldoi to become infected with malaria. The results of these experiments are shown in Table 1.

II Field Studies

A. Malaria Surveys

In cooperation with Commander Ralph D. Comer, MD, USN and Chief Paul Campbell, USN, nine trips were made to the Darien Province, R. P.

The field studies were conducted in the Sambu and Jaque River valleys located in Darien Province, R. P. Doctor Comer and his associates were conducting a program in the Sambu river valley to determine if semi-weekly doses of Primaquine and Pyrimethamine would control malaria. His study had started in July 1966 when approximately 17% of the 2,000 inhabitants of the valley had malaria. In some villages 40-50% of the population was infected. Most of the cases were caused by Plasmodium falciparum. By September the infection had been reduced to 3%. Five trips were made to Sambu.

The Jaque river valley had also been recommended as a good study area and since there was no malaria control program there, four trips were made to that region 1967.

In conducting these studies thick blood smears would be made of all persons while holding medical clinics at numerous sites along the rivers. At night mosquito biting collections would be made. Mosquitoes

on vegetation, walls of buildings and other sites would also be collected. The mosquitoes were aspirated into one pint ice cream cartons covered with bolting cloth, given a sugar solution and placed in chilled insulated pathological boxes. They were transported in these boxes to the laboratory in Corozal where they were identified and examined for protozoa.

The Jaque river valley proved to be only a fair area for these studies because no exceptionally high foci of malaria infection could be found. Approximately 20% of the population were found positive for malaria. Since only 200 persons were living in the study areas the probably of finding infected mosquitoes was limited. The results of the malaria surveys are shown in Table 3.

Anopheles albimanus were the most numerous species in this area, A. oswaldoi was next followed by A. punctimacula. Large areas of the valley had been cleared in past years, so many ground pools were exposed to sunlight providing ideal breeding sites for A. albimanus. The latter was especially true at El Mamey, the largest village. The results of the mosquito collections and subsequent dissections are shown in Table 4. The preponderance of A. albimanus in El Mamey is shown in Table 5. The ratio between A. albimanus and A. oswaldoi was more equal at Lucas as shown in Table 6. The increase in activity near midnight routinely exhibited by A. oswaldoi is also readily apparent from the data in Table 6.

From these studies it appears that Anopheles albimanus is the most important malaria vector in the Jaque river valley. A. oswaldoi and

A. punctimacula may be secondary vectors.

B. Insecticide Investigations

1. Aerial Spray Tests

Despite the fact that the aerial application of insecticides has been extensively used to control Anopheles spp. mosquitoes in SE Asia, there is little information available to indicate it is effective. During the latter part of 1967 exceptionally large populations of Anopheles albimanus and A. triannulatus were present at Frijoles, C. Z. The mosquitoes were uniformly distributed for approximately 10 miles along the shore line of Gatun lake where the tests were made. The population was heaviest near the lake, but large numbers of mosquitoes were also present in the jungle at distances greater than one mile from the lake. There was little diurnal activity in the unshaded areas, but they fed throughout the day in densely shaded jungle areas. Intensive biting began at twilight and continued for several hours, with some biting throughout the night. This was recognized as an excellent area for conducting aerial spray tests because of the heavy Anopheles spp. population, the low malaria risk, the similarity of the terrain and vegetation to that in SE Asia and the convenient means of communication.

These tests were conducted in cooperation with Dr C. S. Lofgren and Dr B. M. Glancey, Entomology Research Division, Agricultural Research Service, USDA, Gainesville, Florida.

Methods and Procedures. The test plots were located adjacent to the right-of-way of the Canal Zone railroad near Darien and Frijoles

stations, and all bordered on or were within several hundred feet of Gatun Lake where larval breeding was known to occur along the lake margins in heavy growth of Elodea. Each plot was about 2,400 feet wide and 1,800 or 2,400 feet deep (about 100-130 acres). Only the boundary along the railroad was measured; the depth was estimated when the insecticide was applied by operating the sprayer for 15 or 20 seconds during the pass over each swath: 15 seconds X 120 feet per second (speed of the plane) = 1,800 feet. All flights were made perpendicular to the tracks. The swaths were marked by smoke delivered from a Dyna-Fog^{R} '150' aerosol generator or by a flag placed on a 24-foot telescoping pole.

Two systems of spray rigs were used in applying the insecticides. One system was supplied by the Medical Equipment Research and Development Laboratories (MERDL) of Ft Totten, New York and was built to fit helicopters of the UH-1 series; it was originally designed to deliver high volume sprays but can be used for ULV sprays also. The second system, supplied by the Entomology Research Division Laboratory at Gainesville, Florida, is small and portable; it consists of a pump, 12-volt motor, and insecticide tank and utilizes flexible polyethylene tubing for conveying the insecticide to the nozzles. The tubing is clamped to the fixed boom of a conventional spray rig. The nozzles are connected to this line and also taped to the fixed boom. TeeJet^{R} No. 80015 flat fan tips were used with both systems.

The helicopter and pilot were supplied by the 193rd Aviation Company, Headquarters, USARSO. The helicopter was operated at 80 m.p.h., and

swaths were 200 feet wide. Since the test areas was hilly, the helicopter could not be maintained at a uniform height above the canopy, but the average height was 100 feet with a range of 50-175 feet. All applications were made between 6 and 10 a. m.

Because of the denseness of the vegetative growth on the plots, it was necessary to have special trails cut for men to follow while assaying the mosquito populations. At the midpoint on the railroad side of each plot, a trail 800 feet long and perpendicular to the railroad track was cut. At the end of this trail two more trails, each 900 feet long, were cut at right angles and in opposite directions thus making a trail 1,800 feet long and parallel to the railroad tracks. Each parallel trail ended about 300 feet from the edges of the plots. All pre- and post-treatment mosquito collections were made along this trail except for a few made along the railroad in the last test. Population estimates were made by collecting with a mechanical aspirator the mosquitoes that landed on the collector. These collections were made along the trails for an hour at 24 locations in the daytime or at nine to ten locations at night.

In the first test, both malathion and fenthion were used, and all except a few collections were made from 1 to 3 p.m.; these few were made from 7:45 to 10:00 a.m. In the second test, only fenthion was applied, and collections were made after dark from 6 to 7:30 p.m. All mosquitoes were returned to the Entomology Laboratory of the Environmental Health Division for identification. (Two species of Anopheles albimanus and A. triannulatus, were collected.) Also, in

the second test, caged A. albimanus (20/cage) were placed along the counting trail of two plots and left there 2 hours after application of the insecticide; these mosquitoes had been transported to the field from the laboratory in styrofoam boxes cooled with refrigerant. In addition, on one plot, oil-red-dye cards were placed on the railroad track and on the ground by the cages to determine the number of droplets deposited per unit area.

Results. The results of the first test (Table 7) showed that applications of 0.1 lb/acre of fenthion and 0.225 lb/acre of malathion did not give satisfactory control of anophelines in the jungle. These rates are within the range generally used for mosquito control in the United States. When the dose of each insecticide was increased about threefold, good control was obtained (85 percent and 90-95 percent, respectively, with malathion and fenthion for as long as 25-30 hours). In the second test, fenthion was applied at the rate of 0.27 lb/acre to three plots, but heavy rain fell on two 4-5 hours after treatment and on the third immediately after treatment. The results were as follows (the 36-hour counts are based on the results from two plots):

Location of collector	Pretreatment count (mosquito/man/hour)	% Control After --- 12 hours	36 hours
In jungle	365	46	69
On railroad	533	49	34

The poorer control in this test can definitely be attributed to the rain on the basis of our experience with aerial sprays in Florida. Presumably this is due to "washing out" of airborne droplets or

foliage residues that could kill mosquitoes that do not contact the insecticide immediately or ones that migrate into the area. All caged mosquitoes in one plot died, and 97.5 percent died in the other. The average number of droplets per square inch was 1.4 in the jungle and 10 on the railroad tracks.

Conclusions. The results showed that control of anophelines can be obtained in moderate to dense jungles with fenthion and malathion though the necessary dose is about three times that required normally. However, this study obviously provided only a limited approach to the problem of mosquito control in jungles, and other methods besides increased doses should be investigated. A study on the relationship between droplet size and penetration through the canopy would be of particular interest.

2. Insect Repellent Studies

During 1967 the insect repellents N,N-Diethyl-m-toluamide (deet), 2,2,4-trimethyl-1,3-pentanediol, dimethyl phthalate, N,N-diethylbenzenesulfonamide, ethyl hexanediol and M-2020 were tested against Anopheles albimanus Wiedmann at Frijoles, Panama Canal Zone. All the repellents except N,N-diethylbenzenesulfonamide provided complete or almost complete protection for the entire test period (> 135 minutes) at the highest concentrations tested. At 25% and 50% ethanol dilutions deet was more effective than M-2020 and 2,2,4-trimethyl-1,3-pentanediol; dimethyl phthalate was the least effective of the four repellents. At 10% dilutions deet was significantly more effective than the other three repellents while

M-2020 and 2,2,4-trimethyl-1,3-pentanediol were about equally effective and significantly more effective than dimethyl phthalate.

3. Insecticide Residue Tests

A series of insecticide tests in cooperation with Mr J. B. Gahan, Entomology Research Division, Agricultural Research Service, USDA, Gainesville, Florida were conducted to determine the effectiveness of insecticide residues on U. S. Army tenting against Anopheles spp.

In laboratory tests in Florida, Dursban, diazinon and Baygon wettable powders and emulsifiable concentrates, applied to canvas tenting at the rate of $2gm/m^2$, gave 100% kill of Anopheles quadrimaculatus for 24 weeks following a one hour exposure to the treated surface. Mobam wettable powder was also effective for 24 weeks, but the emulsifiable concentrate failed between the first and fourth week. Malathion, Chlordane and DDT were ineffective the first week. In field tests in Panama where U. S. Army General Purpose tents were sprayed at the rate of $1gm/m^2$, Dursban was superior to diazinon, Baygon and Malathion against Anopheles albimanus. DDT was ineffective in the field tests also. Dursban emulsifiable concentrate offers promise for the treatment of Army tenting.

C. Pesticide Dispersal Equipment Evaluation and Development

1. Insecticide Tests with the Mity Mite Insecticide Sprayer

The Buffalo Turbine Company, Mity Mite back-pack sprayer has been widely distributed to DOD Agencies for insect control. Preliminary tests by the Environmental Health Division, Office of

the Chief Surgeon, HQ USARSO and informal comments by various individuals, however, indicated the item was not satisfactory for spraying liquid insecticides.

A series of tests were conducted with modified machines to determine if the item was suitable for the Ultra-low-volume application of concentrated insecticides.

The machine was modified by replacing the insecticide tank with a 1 quart Nalgene plastic tank, replacing the outlet hose with a flexible polyethylene tube and placing a perforated disc in the line to restrict the flow. Tests were conducted with 57% and 95% Malathion and Baytex 4 and 8 pound/gallon formulations.

Tests were conducted against caged Anopheles albimanus mosquitoes, A. albimanus larvae exposed in plastic cottage cheese containers. Tests were also conducted against natural populations of Anopheles spp. adults and larvae.

Baytex was found to be slightly superior to Malathion. Excellent kill of natural populations of Anopheles larvae was obtained, but the control of natural adult populations was poor. The modified machines were more satisfactory than the standard item of issue. This equipment appears to have limited value for troop use in thickly forested and hilly terrain because of the difficulty in transporting it.

2. Portable Insect Light Trap

Several compact portable insect light traps were made to use for conducting mosquito surveys. These were similar to the one

described by Chamberlain and Sudia and commonly called the "CDC portable insect light trap". The primary differences are, use of a Barber-Coleman Co. 6-volt electric motor, use of a smaller (3") plexiglas tubing to hold the body of the trap, use of a cubical insect collecting cage, use of a 10 inch rain shield and a simplified wiring system.

The trap has worked well in preliminary field tests and additional tests are in progress. The primary advantage of the trap is its compactness and portability.

3. Development of Dispenser, Insecticide, Liquid, Ultra-low-volume, Rotary Wing Aircraft

Two dispensers were constructed, one for the H-13 helicopter and one for the UH-1 series of helicopters.

For the H-13 helicopter a 20 gallon stainless steel tank was attached to the landing gear in the same manner that a litter pod is attached. The spray boom was fabricated out of 1 inch 2024 STS Aluminum, with 0.120 wall thickness and attached to the landing gear by eight bolts. A 24-volt aircraft fuel transfer pump was used to pump the insecticide. Flexible polyethylene tubing is utilized for conveying the insecticide to the nozzles. The tubing and nozzles are clamped to the boom. Nylon Tee-Jet nozzles and a variety of flat fan tips are used with the system. The unit can be mounted on the aircraft in 20-30 minutes and requires no modification. Excellent adult and inmature Anopheles spp. has been obtained using this dispenser with undiluted insecticide.

The dispenser for the UH-1 helicopter is very similar except it has a 25 gallon stainless steel tank and the unit fastens to the floor of the aircraft with the booms extending out of the doors on each side.

Use tests with both items will be continued.

4. Evaluation of Dispenser, Insecticide, Solid, Rotary Wing Aircraft

In May and June 1968 a service test was conducted with the Dispenser, Insecticide, Solid, Rotary Wing Aircraft, that had been developed by the Medical Equipment Research and Development Laboratory, Fort Totten, N. Y. This item was designed for use on the UH-1 helicopters and can be used to apply insecticide dusts or granules.

The tests demonstrated that it is an excellent item of equipment and that excellent Anopheline larvae control can rapidly be obtained over large areas.

List of Publications:

1. Anopheline Control in the Canal Zone with Ultra-Low Volume Sprays of Malathion and Fenthion, C. S. Lofgren, R. M. Altman and B. M. Glancey. Submitted for publication in Mosquito News.

2. Repellent Tests Against Malaria Vectors in the Panama Canal Zone. Robert M. Altman. Approved by OTSG for publication.

3. The Effectiveness of Insecticide Residues on U. S. Army Tenting Against Anopheles spp. Robert M. Altman and James B. Gahan. Submitted for publication in Mosquito News.

4. Service Test, Dispenser, Insecticide, Solid, Rotary Wing Aircraft, Test Monitor; Robert M. Altman. Sent to Combat Development Command 3 July 1968.

R. M. ALTMAN
COL, MSC
Entomologist

Table 1--Results of Malaria infection experiments with Anopheles oswaldoi.

*Numerator = Number Positive Denominator = Number mosquitoes dissected.

Date fed	Monkey	Malaria	Parasite count mm^3	Number applied to Monkey	Number fed	Number Dissected day			Results of Infection attempts with A. albimanus	
						6-8	10	12	14	same date	other date
25 Sep 67	Night Monkey 257 B	P. vivax	4150	200	20	0/3*			0/8		0/20
25 Sep 67	Black Spider 232 B	P. braziliensis	22090	100	50	0/9					0/93
2 Oct 67	Night Monkey 257 B	P. vivax	280	1000	185	0/10		0/5	0/16		
2 Oct 67	Black Spider 232 B	P. braziliensis	33290	1000	52	0/3			0/5		
16 Oct 67	Night Monkey 265 B	P. vivax	14170	80	14				0/3		0/65
16 Oct 67	Night Monkey 290 B	P. vivax	11450	50	6				0/4		0/40
6 Nov 67	Night Monkey 294 B	P. vivax	10950	100	32				0/2		33/395
6 Nov 67	Night Monkey 303 B	P. vivax	2120	150	46				0/7		9/65

Table 1--Results of Malaria Infection experiments with Anopheles oswaldoi. (Continued)

*Numerator = Number Positive Denominator = Number mosquitoes dissected.

Date fed	Monkey	Malaria	Parasite count mm^3	Number applied to Monkey	Number fed	Number Dissected day			Results of Infection attempts with A. albimanus	
						6-8	10	12	14	same date	other date
21 Nov 67	Night Monkey 294 B	P. vivax	8340	100	33		0/5		0/3		
16 Dec 67	Night Monkey 375 B	P. vivax	9180	50	6	0/5					38/177
18 Dec 67	Night Monkey 375 B	P. vivax	7330	35	5	0/2					
21 Dec 67	Night Monkey 412 B	P. vivax	3680	13	1	0/1				0/17	43/373
29 Dec 67	Night Monkey 412 B	P. vivax	18800	125	12	0/9				1/25	42/365
2 Jan 68	Night Monkey 412 B	P. vivax	8600	128	22	0/1				0/20	43/370
4 Jan 68	Night Monkey 412 B	P. vivax	6110	75	11	0/1				0/20	43/370
8 Jan 68	Night Monkey 434 B	P. vivax	32000	25	5						

Table 2--Results of Anopheles mosquito surveys in Sambu River Valley, Darien, R. P.

Date	Number Anopheles Collected							Number Dissected						
	alb	punct	tri	osw	squ	neo	apic	alb	punct	tri	osw	squ	neo	apic
27-30 Sep '66	14	690	70	46										0/9*
14-17 Nov '66	11	188			1	253	8		0/1					0/21
15-18 Jan '67		162	7	9			3							
30-31 May '67		13	3	23										
19-21 Sep '67		7	1	3										

REMARKS

alb - Anopheles albimanus
punct - " punctimacula
tri - " triannulatus
osw - " oswaldoi
squ - " squamifemur
neo - " neomaculipalpus
apic - " apicimacula

*Numerator = Number positive
Denominator = Number Dissected

Table 3--Results of Malaria Surveys in Jaque River Valley in Villages of Lucas, El Mamey and Pavarando, Darien, R. P.

Date	*P. vivax*	*P. falciparum*	*P. spp*	Mixed infect.	Neg.	Total	% Pos.
27-30 Jan '67	13	5	6				
7-10 Apr '67	4	11	20	1	145	181	20
14-16 Aug '67	1	4	4		36	43	16

Table 4--Results of Anopheles mosquito surveys in Jaque River Valley, Darien, R. P.

Date	Number Anopheles Collected						Number Dissected					
	alb	punct	tri	osw	apic	pseudo	alb	punct	tri	osw	apic	pseudo
28 Jan '67	58	1	2	12			0/17*		0/1	0/5		
15-16 Feb '67	269	33	17				1/190	0/30	0/7			
3-10 Apr '67	5762	228	1236	11	34		0/443	0/13	0/45		0/8	
14-16 Aug '67	5	252	293	32			See Note below					

REMARKS:

alb - Anopheles albimanus
punct - " punctimacula
osw - " oswaldoi
apic - " apicimacula
pseudo - " pseudopunctipennis

*Numerator = Number positive
Denominator = Number dissected

Note - 292 more were dissected, none were positive

Table 5--Summary of Anopheles spp. Collection in El Mamey, R. P. 3-10 April 1967. 2 nights, 5 collectors, 34 man-hours.

Species	Number
Anopheles albimanus	4144
Anopheles oswaldoi	8
Anopheles pseudopunctipennis	18
Anopheles punctimacula	19
Anopheles apicimacula	5

Table 6--Summary of Anopheles spp. man-biting collections at Lucas, Darien. 3-10 April 1967. 4 nights, 66 man-hours, 5 collecting sites.

Species	Number Collected at Indicated Time		
	1800-2000	2000-2200	2200-2400
A. albimanus	345	424	340
A. oswaldoi	149	431	319
A. punctimacula	49	51	45
A. pseudopunctipennis	6		1
A. apicimacula	2	1	

Table 7--Reduction of Anopheles spp. obtained with ULV sprays of malathion and fenthion in jungles in the Panama Canal Zone (averages for duplicate plots).

Insecticide	Rate of Application (lb./acre)	Rate of Application (fl.oz./acre)	Pre-treatment count (mosquito/man/hour)	% Control after indicated hours: 6	25-30	49-52	72
Malathion	0.225	3	62	63	0		
(95% tech)	.62	8	87	78	85	75	
Fenthion	.1	1.6	131	59	62		
	.25	4	72	80	90		
	.32	4.8	33	38	95	a/	0
(Check)			172	0	0	0	0

a/ Collections of Mosquitoes could not be made because of rain.

DISTRIBUTION LIST

4 copies to:	Commanding General U. S. Army Medical Research and Development Command ATTN: MEDDH-SI Washington, D. C. 20315
20 copies to:	Defense Documentation Center ATTN: DDCIR Cameron Station Alexandria, Virginia 22314
1 copy to:	Commanding Officer U. S. Army Combat Development Command Medical Service Agency Brooke Army Medical Center Fort Sam Houston, Texas 78234

1. ORIGINATING ACTIVITY (Corporate author) Office of the Chief Surgeon HQ, US Army Forces Southern Command Fort Amador, Canal Zone	2a. REPORT SECURITY CLASSIFICATION 2b. GROUP

3. REPORT TITLE

A Study of the Ecology of Malaria Vectors in the Republic of Panama

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report (1 Oct 66 - 13 Jul 68)

5. AUTHOR(S) (First name, middle initial, last name)

Robert M. Altman, Col, MSC

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1968	23	--

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
None b. PROJECT NO. 3A6353011D829 00 037	None
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) RCS MEDDH-288(R1)
d.	

10. DISTRIBUTION STATEMENT

This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
None	U.S. Army Medical R&D Command Washington, D. C. 20315

13. ABSTRACT

Malaria surveys and mosquito ecology studies were conducted in endemic areas in the Republic of Panama, various laboratory investigations as well as insecticide and insect repellent evaluations were also conducted. Nine malaria surveys confirmed opinions that Anopheles albimanus is the primary vector in the Sambu and Jaque river valleys although other species may be secondary vectors. Unsuccessful attempts were made to colonize A. oswaldoi and other Anopheles spp. A. oswaldoi could not be infected by feeding them on monkeys infected with Plasmodium vivax. Aerial applications over the jungle of undiluted technical Fenthion applied at 0.32 pounds/acre reduced the Anopheles spp. population 95% after 25-30 hours, malathion applied at 0.62 pounds/acre gave 85% reduction after 25-30 hours. Insecticides were evaluated against Anopheles spp. on Army tenting; Malathion, Chlordane and DDT were ineffective after one week, Dursban was the most promising insecticide tested. N,N-diethyl-m-toluamide (deet) was the most effective of several repellents tested against A. albimanus in the field. Satisfactory equipment was designed and constructed for mounting on H-13 and UH-1 Helicopters for spraying concentrated insecticides. Other insect control methods were also evaluated.

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Security Classification

Malaria, mosquito, ecology, survey, control, insecticides, Anopheles, repellents, Penthion, Malathion, Dursban, DDT, Chlordane, equipment, helicopter, aerial application, N,N-diethyl-m-toluamide, deet

Security Classification